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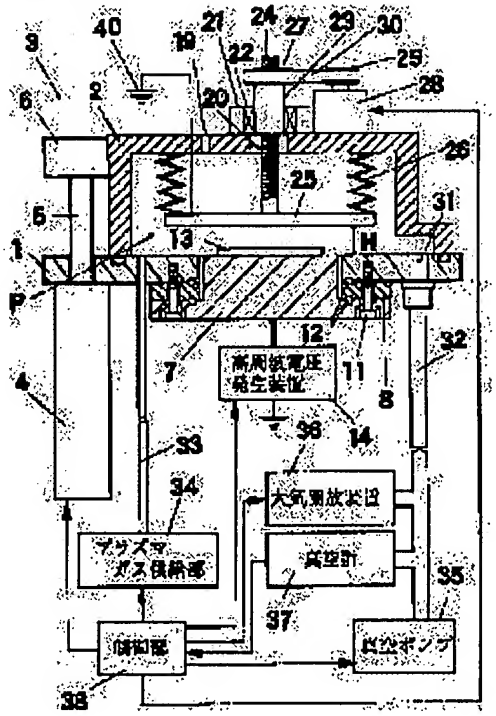
(54) PLASMA TREATMENT DEVICE AND ITS TREATMENT METHOD FOR WORK

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a plasma treatment device and its method by which vacuum absorption is possible in a short time by a vacuum pump with a small capacity, the most appropriate treatment condition is set for every work to be treated.

SOLUTION: A movable barrier plate composed of a plate 25 and a bellows 26 is provided in a plasma space P surrounded by a base member 1 and a surrounding wall 2. A volume of the plasma space P in a vacuum chamber 3 and an electrode space distance H between a lower electrode 7 and an earth electrode are changed by moving a plate which serves also as an earthing electrode up and down with a moving means comprising a motor 28 and a feed screw 24. Thereby, while a vacuum absorbing time is shortened substantially by reducing a volume when performing vacuum absorbing, the most appropriate plasma treatment condition corresponding to a work 13 can be set by changing the electrode space distance H, so that an efficient and uniform plasma treatment is materialized.



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)ETAILED DESCRIPTION

Detailed Description of the Invention]
0001]
Field of the Invention] This invention relates to the plasma treatment equipment of the work piece which carries out)lasma treatment of the front face of a work piece, and the plasma treatment approach of a work piece.
0002]
Description of the Prior Art] The plasma treatment approach is learned as an approach of performing various kinds of)rocessings, such as tailing of the front face of work pieces, such as a substrate, and surface coat formation. It is what)lasma treatment decompresses [what] the processing room in a vacuum chamber, and high-frequency voltage is mpressed [what] to one electrode of the two electrodes which face under this reduced pressure ambient atmosphere, ınd generates the plasma. Remove a surface foreign matter by making the electron and ion which this produced collide)n the surface of a processing object, or a front face is activated, An electron and ion are made to collide with the matter hich forms a surface coat, the particle of this matter is dispersed, and making it adhere on the surface of a processing)bject is performed.
0003] Since plasma treatment is performed under reduced pressure, after containing the work piece which is a)rocessing object in a vacuum chamber, and usually performing carrying out vacuum attraction of the inside of a vacuum :hamber with vacuum attraction means, such as a vacuum pump, and completing plasma treatment, introducing ıtmospheric air and returning in a vacuum chamber, at ordinary pressure is performed.
0004]
Problem(s) to be Solved by the Invention] Vacuum attraction of the inside of the vacuum chamber of a certain volume i: :arried out, and in order to make the processing interior of a room reach a necessary degree of vacuum, necessary 'educed pressure time amount is required. Generally this reduced pressure time amount is about dozens of seconds. The ime amount of these seconds of dozens of was quite long as a tact time of the production process of electronic parts, or a nounting process, and in order to raise productivity, shortening this reduced pressure time amount was called for. Iowever, with conventional plasma treatment equipment, if it is necessary to use a mass vacuum pump, and is going to :horten reduced pressure time amount and will do in this way, the trouble of causing enlargement and a cost rise of :quipment will arise.
0005] Moreover, while the oil generally used for the lubrication of a vacuum pump at the time of operation of a vacuum)ump exhausts, it becomes a particle and mixes, and it becomes oil mist and is discharged. When the amount of this oil nist has a relation of being proportional to the volume of the vacuum chamber for vacuum attraction and opens and :loses a vacuum chamber with the big volume by high frequency, its degree with which the atmospheric air of the)lasma treatment equipment circumference is polluted by the oil mist discharged from a vacuum pump will increase. In he production line of the electronic parts which need especially high cleanliness, since contamination of the air by this)il mist was not permitted, it had the trouble that it will be necessary to form a large-scale outdoor exhaust air facility on he outskirts, with the big plasma treatment equipment of a throughput.
0006] Furthermore, with conventional plasma treatment equipment, although the optimal inter-electrode distance :hanged with forms of a work piece when plasma treatment was performed, since the location of an electrode was being ixed, there was a trouble that plasma treatment was not necessarily performed on the optimal conditions for each work)iece.
0007] Then, this invention can carry out vacuum attraction also in a vacuum chamber with the big volume to a degree o: acuum necessary with a short time in the vacuum pump of small capacity, and can decrease the yield of oil mist, and ıims at offering the plasma treatment equipment and the plasma treatment approach which can perform setting out of the)ptimal processing conditions for every form of a work piece further.

0008]
Means for Solving the Problem] The lower electrode with which plasma treatment equipment according to claim 1 has been arranged at the vacuum chamber, The RF generator which impresses high-frequency voltage to a lower electrode, and the earth electrode prepared above the lower electrode, The vacuum attraction means which carries out vacuum attraction of the processing room of said vacuum chamber, and the plasma gas feed zone which supplies the gas for plasma generating to a processing room, It has atmospheric-air disconnection equipment which opens a processing room to atmospheric air, while forming a movable septum in the interior of said enclosure, the migration means to which a movable septum is moved is established, and it enabled it to change the volume of said processing room by moving a movable septum.
0009] Invention according to claim 2 enabled it to change the inter-electrode distance of said lower electrode and said earth electrode in plasma treatment equipment according to claim 1 by moving said earth electrode in one with said movable septum.
0010] Moreover, the plasma treatment approach according to claim 3 contains a work piece in the processing room of a acuum chamber. And the process which carries out vacuum attraction of the processing room with a vacuum attraction neans where the volume of a processing room is made small by the movable septum with which the vacuum chamber as equipped, and supplies the gas for plasma generating to a processing room from a plasma gas feed zone, The proces hich a processing room is made to generate the plasma and carries out plasma treatment of the front face of a work piece by impressing high-frequency voltage to a lower electrode where the volume of a processing room is enlarged by he movable septum, and where the volume of a processing room is made again small by the movable septum Air is sent o a processing room, a processing room is returned to ordinary pressure, and it was made to include the process which opens a vacuum chamber and takes out a work piece.
0011]
Embodiment of the Invention] Since the attraction volume at the time of carrying out vacuum attraction by changing the olume of the processing room which is made to move a movable septum and is formed in a vacuum chamber can be lecreased according to claim 1 and invention according to claim 3, the amount of the oil mist which can reach a necessary degree of vacuum also with the vacuum pump of small capacity in a short time, and is generated from a acuum pump can be reduced.
0012] Moreover, according to invention according to claim 2, the optimal plasma treatment conditions according to a ork piece can be set up by making an earth electrode movable and changing inter-electrode distance.
0013] Next, the gestalt of operation of this invention is explained with reference to a drawing. The sectional side elevation of the plasma treatment equipment of the gestalt of 1 operation of this invention, drawing 2 , drawing 3 , lrawing 4 , drawing 5 , drawing 6 , drawing 7 , and drawing 8 of drawing 1 are the fragmentary sectional views of this plasma treatment equipment.
0014] First, the whole plasma treatment equipment structure is explained with reference to drawing 1 . In drawing 1 , he covering device 2 of a cube type is arranged on the base member 1. The base member 1 and a covering device 2 constitute the vacuum chamber 3. The edge of the base member 1 is equipped with the cylinder 4, and the point of the od 5 of a cylinder 4 is equipped with the block 6. The block 6 is combined with the covering device 2 in one. Therefore, f the rod 5 of a cylinder 4 ****, a covering device 2 will move up and down on the base member 1, and the vacuum chamber 3 will be opened and closed.
0015] Opening is prepared in the center section of the base member 1, the opening is penetrated, and it is equipped with he lower electrode 7. The insulating plate 8 is arranged between the lower electrode 7 and the underside of the base nember 1. On both sides of the insulating plate 8, the underside of the base member 1 is equipped with the lower electrode 7 with the bolt 11. Moreover, it is equipped with the seal 12 between the underside of the base member 1, and he insulating plate 8, and between the insulating plate 8 and the lower electrode 7, if vacuum attraction of the inside of he vacuum chamber 3 is carried out, the lower electrode 7 will be pushed against base member 1 underside by the air pressure deficit, a seal 12 is crushed according to this forcing force, and a sealing surface is sealed.
0016] The work piece 13 set as the object of plasma treatment is laid in the top face of the lower electrode 7. Moreover, he lower electrode 7 is electrically connected to the high-frequency-voltage generator 14 which is an RF generator. The high-frequency-voltage generator 14 impresses high-frequency voltage to the lower electrode 7.
0017] Openings 19 and 20 are formed in the top face of a covering device 2. Opening 19 is an air hole which makes the nterior of a covering device 2 open for free passage outside. The top face of opening 20 is equipped with the bearing block 21. The interior of the bearing block 21 is equipped with the bearing 22, and the nut 23 has inserted in a bearing 22. The feed screw 24 is thrusting into the nut 23, and the plate 25 is combined with the soffit section of a feed screw 24. The periphery section of a plate 25 is equipped with the soffit section of the telescopic bellows 26 for airtight, and the

ıpper bed section of bellows 26 maintains an airtight at the head-lining side of a covering device 2, and is combined witl t.:

0018] The pulley 27 is combined with the upper bed section of a nut 23. Moreover, the motor 28 is arranged in the top ace of a covering device 2, and the revolving shaft of a motor 28 is equipped with the pulley 29. The belt of the belt 30 s carried out to the pulley 27 and the pulley 29. Therefore, by driving a motor 28, a nut 23 rotates and the plate 25 :ombined with the soffit section of a feed screw 24 moves up and down inside a covering device 2. That is, a plate 25 ınd bellows 26 serve as a movable septum which moves in the space in the vacuum chamber 3 while maintaining an ıirtight, and the nut 23, the feed screw 24, the motor 28, etc. serve as a migration means to move a plate 25 in the vertica lirection. Moreover, the space surrounded with the base member 1, a covering device 2, a plate 25, and bellows 26 form: he processing room P. Therefore, if a plate 25 moves up and down, the volume of the processing room P decreases, and f it goes up, this volume will increase. Moreover, the plate 25 is electrically grounded by the touch-down section 40, anc :erves as an earth electrode which faces the lower electrode 7.

0019] The breakthrough 31 is formed in the right edge of the base member 1. Piping 32 is connected to the ›reakthrough 31. The vacuum pump 35, the atmospheric-air disconnection equipment 36, and the vacuum gage 37 whicl ıre a vacuum attraction means are connected to piping 32. Moreover, piping 33 is connected to the left end section of the ›ase member 1, and the plasma gas feed zone 34 is connected to piping 33. A control section 38 receives the signal from ı vacuum gage 37, and controls actuation of each part of a motor 28, the high-frequency-voltage generator 14, ıtmospheric-air disconnection equipment 36, a vacuum pump 35, and the plasma generating gas supply section 34.

0020] The plasma treatment equipment of this work piece consists of the above configurations, and explains that ıctuation with reference to each drawing below. In addition, drawing 2 - drawing 7 show a series of actuation in order of ıctuation. First, the rod 5 (refer to drawing 1) of a cylinder 4 projects, a covering device 2 goes up, and drawing 2 shows he condition that the vacuum chamber 3 serves as open. A work piece 13 is laid on the lower electrode 7 in this :ondition. At this time, a plate 25 is in a downward location.

0021] Next, as shown in drawing 3 , a covering device 2 descends and the vacuum chamber 3 is closed. Vacuum ıttraction in the vacuum chamber 3 is performed through piping 32 next (refer to arrow-head a). In this condition, since he processing room P formed on the base member 1, the covering device 2 which is an enclosure, and the plate 25 whicl s a movable septum has a plate 25 in a downward location as mentioned above, the volume is decreasing (if it compares ith the time of plate 25 lifting, it will decrease to about 1/50 volume). Therefore, reduced pressure time amount until it eaches a necessary degree of vacuum is shortened substantially.

0022] Subsequently, a motor 28 is driven, the plate 25 which is a movable septum is moved up, continuing vacuum ıttraction, as shown in drawing 4 , (refer to arrow-head b), and the volume of the processing room P is increased. Thereby, while the degree of vacuum in the processing room P rises further, the inter-electrode distance H according to he work piece 13 set as the object of plasma treatment is set up.

0023] Next, as shown in drawing 5 , the plasma generating gas supply section 34 drives, and the gas for plasma ;enerating, such as argon gas, is introduced into the processing interior of a room from piping 33 (refer to arrow-head c). Subsequently, the high-frequency-voltage generator 14 is driven and high-frequency voltage is impressed to the lower :lectrode 7. Thereby, the plasma occurs to the space between the lower electrode 7 and the plate 25 which functions as :arth electrodes (refer to the part which performed hatching in drawing 5). In this case, since the inter-electrode distance H of the lower electrode 7 and a plate 25 is set as the distance according to the target work piece 13, the optimal plasma :onditions according to a work piece 13 are realized.

0024] Here, the relation between the inter-electrode distance H and the optimal plasma conditions is explained with eference to drawing 8 . Drawing 8 (a) shows the condition of the plasma processing indoor when the inter-electrode listance H1 is small with a small work piece 13, and drawing 8 (b) shows the condition that a work piece is large-scale ınd processing indoor when the inter-electrode distance H2 is large. In drawing 8 (a) and (b), the roughness and fineness ›f hatching performed between the lower electrode 7 and the earth electrode 25 show distribution of the etching rate hich shows the degree from which the front face of a processing object is deleted in the consistency of the plasma agair ith the electron which generates Graph f by the plasma, or ion.

0025] As shown in drawing 8 (a), when the inter-electrode distance H1 is small, the part with the high consistency of he plasma is concentrating on the center section of the processing room, and an etching rate also serves as a big value by ›art for the center section of a processing room, and it has become the distribution which decreases on the outskirts. That s, if a work piece 13 is located near the center of a processing room and inter-electrode distance H1 is made small, :fficient plasma treatment can be performed to process the small work piece 13 for a short time.

0026] on the other hand -- although the plasma consistency of the processing interior of a room is low when the inter- :lectrode distance H2 is large as shown in drawing 8 (b) -- processing -- it becomes homogeneity about the whole

:hamber, and the etching rate also shows uniform distribution. namely, the big work piece 13 -- or when putting two or nore small work pieces in order and processing them, uniform plasma treatment can be performed over the large range by enlarging inter-electrode distance H.

0027] Thus, the optimal plasma treatment conditions can be set up by setting up the inter-electrode distance H ippropriately according to the difference between the magnitude of a work piece 13, a processing-object part, etc.

0028] Next, if the plasma treatment of a work piece 13 is completed, as shown in drawing 6 , a motor 28 will be driven, plate 25 will be dropped (refer to arrow-head d), and the volume of a processing room will be decreased again. Subsequently, atmospheric-air disconnection equipment 36 is driven and atmospheric air is introduced through piping 32 n the processing room P. Since the volume of the processing room P is decreasing also in this case, the time amount aken to introduce atmospheric air into the processing room P, and to return the processing room P to ordinary pressure is shortened substantially.

0029] Next, as shown in drawing 7 , a cylinder 4 is driven, a covering device 2 is raised, and the vacuum chamber 3 is changed into an open condition. Subsequently, 1 cycle of ejection and plasma treatment ends the work piece 13 which completed plasma treatment from the inside of the vacuum chamber 3.

0030] Although he is trying to change the inter-electrode distance H while changing the volume of the processing room by not limiting this invention to the gestalt of the above-mentioned implementation, for example, the plate 25 which is movable septum serving as an earth electrode with the gestalt of the above-mentioned implementation, and moving a plate 25 up and down, an earth electrode is used as a movable septum and another object, and its separate ****** is also good. Moreover, what is necessary is just to make it the structure where the volume of the processing room of a vacuum chamber can be changed, maintaining the airtight of a movable septum in short, although the combination of a plate 25 and bellows 26 is used as a movable septum with the gestalt of the above-mentioned implementation.

0031]

Effect of the Invention] Since the attraction volume at the time of carrying out vacuum attraction by changing the olume of the processing room which is made to move a movable septum and is formed in a vacuum chamber can be decreased according to claim 1 and invention according to claim 3, even if it is the vacuum pump of small capacity, a necessary degree of vacuum can be reached extremely in a short time. Therefore, since the amount of the oil mist generated from a vacuum pump can be reduced while compaction of a tact time is realized, surrounding atmospheric air s not polluted and facility costs, such as a large-scale outdoor exhaust air facility, can be reduced.

0032] Moreover, according to invention according to claim 2, by moving an earth electrode in one with a movable septum, and changing inter-electrode distance, the optimal plasma treatment conditions according to a work piece can be set up, and plasma treatment with it is realized. [it is efficient and homogeneous]

Translation done.]